Technical Report Series

Bacterial Study of Chippewa Beach – Thunder Bay, Ontario 1989

THUNDER BAY

NORTH SHORE
OF LAKE SUPERIOR
REMEDIAL ACTION PLANS

BACTERIAL STUDY OF

CHIPPEWA BEACH - THUNDER BAY, ONTARIO

1988

CORPORATION OF THE
CITY OF THUNDER BAY
500 Donald St. E.
Thunder Bay, Ontario

MINISTRY OF THE ENVIRONMENT
Northwestern Region
Thunder Bay, Ontario

THUNDER BAY DISTRICT
HEALTH UNIT
999 Balmoral St.
Thunder Bay, Ontario

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PREPARED BY:

G. S. IRWIN
Microbiologist
Ontario Ministry of the Environment

SUMMARY

Chippewa Beach is subject to periodic bacterial contamination which renders the bathing area unsuitable for swimming during prolonged periods each summer. Previous studies (1985) had indicated that local sources such as feces from waterfowl and other animals were responsible for the high levels of fecal coliforms in the bathing area. However, this view was not universally accepted. An alternate theory that the fecal bacteria were arising from external sources (i.e. outside the park) was proposed. Remedial measures could not be initiated until this question was resolved.

Therefore, in the summer of 1988, a detailed survey of the bacterial water quality of the bathing area at Chippewa Beach was undertaken. The results confirmed the findings of the 1985 study that the fecal bacterial contamination of the bathing area was caused, primarily, by the intestinal wastes of waterfowl and other wildlife at the park. In particular, the flock of 25 or more Canada geese that were common inhabitants of the park appeared to be the main culprits fouling both the sand beach and the bathing area with their droppings. Other waterfowl such as ducks and gulls added to the problem.

The droppings from this flock of geese were observed on different occasions along the sand of the beach at the waters edge and in the shallow water of the primary bathing area. This was the same area where small children preferred to play. Several of the droppings were analyzed. Each contained approximately 100 million fecal coliform bacteria. These wastes were flushed into the bathing area by stormwater runoff. High waves tended to break up the droppings and distribute the fecal bacteria throughout the bathing area or resuspend any bacteria that may have fallen into the sediments under the bathing area.

A plume containing bacterial contaminants was found in Lake Superior outside the lagoon at Chippewa Beach. This plume contained high levels of total coliform bacteria but relatively low levels of fecal coliforms and <u>E. coli</u>. The bacterial levels in this plume were highest at the mouths of the three rivers on the Kaministikwia River system and then gradually decreased the further south it was carried by the currents. The plume was easily detected as far south as Sandy Beach.

Nevertheless, there was no evidence that external sources such as the Thunder Bay Sewage Treatment Plant or industries on the Kaministikwia River system were contributing to the fecal bacterial levels in the bathing area at Chippewa Beach.

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INTRODUCTION

The water in the bathing area at Chippewa Beach is subject to periodic contamination by fecal coliform bacteria. Over the past several years, the bacterial contamination has prevented bathing activities at this beach for prolonged periods of time. This problem has been occurring at Chippewa Beach for a number of years and has yet to be rectified.

During the summers of 1984 and 1985, two studies were undertaken to determine the source of the bacterial contaminants in the bathing area at Chippewa Beach (1,2). These studies were conducted by the Ministry of the Environment. The 1985 report concluded that the high levels of fecal coliform bacteria in the bathing area were caused by local sources of fecal material. These sources were present at the Park. The bacterial contamination of the bathing area was a result of fecal wastes from local birds and animals being flushed into the bathing area by stormwater runoff and/or being resuspended into the water column by the action of high waves.

This view, however was not shared universally. An alternate theory about the cause of the fecal bacterial contamination of the bathing area was that sources outside the Park (or external sources) were responsible for the contamination. The contaminants were believed to be arising as domestic and/or industrial wastes from the sewage treatment plant or industries on the Kaministikwia River system and entering the bathing area *via* Lake Superior.

Unfortunately, remedial measures could not be initiated until all agencies were agreed upon the sources of the fecal bacterial contamination of the bathing area at Chippewa Beach. Therefore, a further study was undertaken to examine, in greater detail, the sources of the contamination and arrive at an opinion acceptable to all agencies involved.

The Chippewa Beach Joint Study was established in 1988 as a cooperative effort between the Corporation of the City of Thunder Bay, the Thunder Bay District Health Unit and the Ministry of the Environment.

The study was divided into two main components:

1. To determine the source(s) of the fecal bacterial contamination of the bathing area.

2. To provide solutions to the problem once the source(s) had been determined.

This report provides information on the first component of the Chippewa Beach Joint Study.

METHODS

A complete description of the methods used in this study is given in the report 'Thunder Bay Beaches, 1984'(1). 'Less than' and 'greater than' bacteriological data were handled in the fashion outlined in the report 'Thunder Bay Beaches, 1985'(2).

I. SAMPLING STATIONS

1. OFF-BEACH STATIONS

(a) RIVER MOUTHS

KAM Kaministikwia River, mid stream, below STP outfall, in front of Esso dock
MCKL McKellar River, mid stream, by the coal belts
MISS Mission River, mid stream, in front of fence at mouth

(b) LAKE SUPERIOR

LSI1 150 m off Abitibi boom, NE corner, on line with northern boundary
LSI2 150 m off disposal site boundary, at start of gray rocks (junction of Abitibi boom)
LSI3 150 m off disposal site, at mid point of eastern boundary
LSI4 150 m off disposal site at SE corner, on line with SE boundary
LSI5 200 m outside lagoon, on line with wharf
LSI6 200 m outside lagoon, on line with small white building
LSI7 150 m off Whiskeyjack Point, on line with north side of point
LSI8 200 m off Sandy Beach

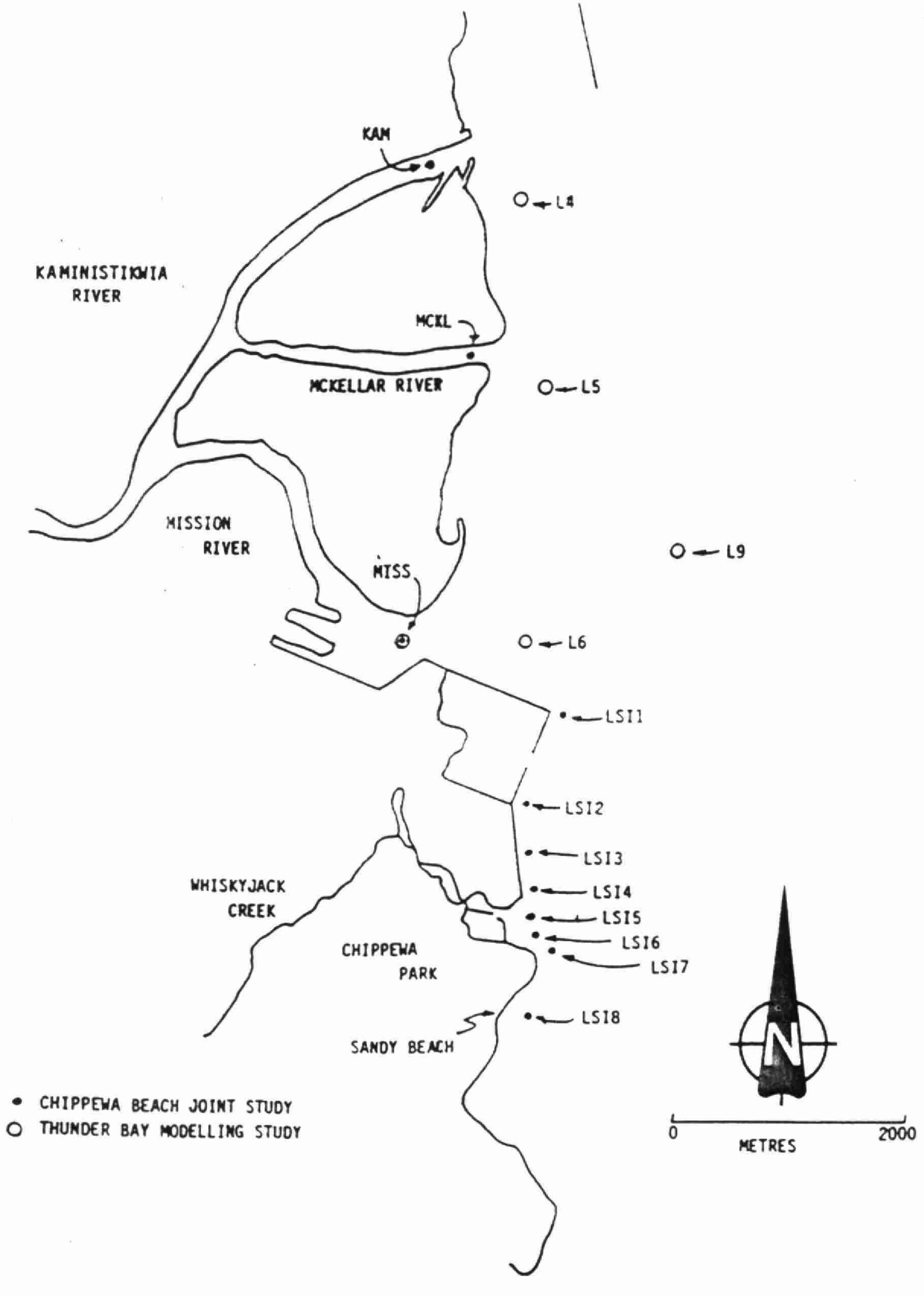
(c) DITCHES

CPI1 Ditch crossing playing field, at culvert
CZ02 Stream from zoo, just before the beach

(d) WHISKEYJACK CREEK SYSTEM

CPI2 Above bridge by campground
CPI3 At the narrows below the campground
CPI4 Off rock at mid point of wharf
CPI5 Off rocks at end of wharf

Figure 1. Locations of selected off-shore sampling stations for Chippewa Beach Joint Study and Thunder Bay Modelling Study.



(e) BREAKWATER STATIONS

CPI6 Off breakwater at bend
CPI7 Off mid point of breakwater
CPI8 Off rocks at base of breakwater
CPI9 Off rocks halfway between base of breakwater and Whiskeyjack Point

2. BATHING AREA STATIONS

(a) CHIPPEWA BEACH BATHING AREA

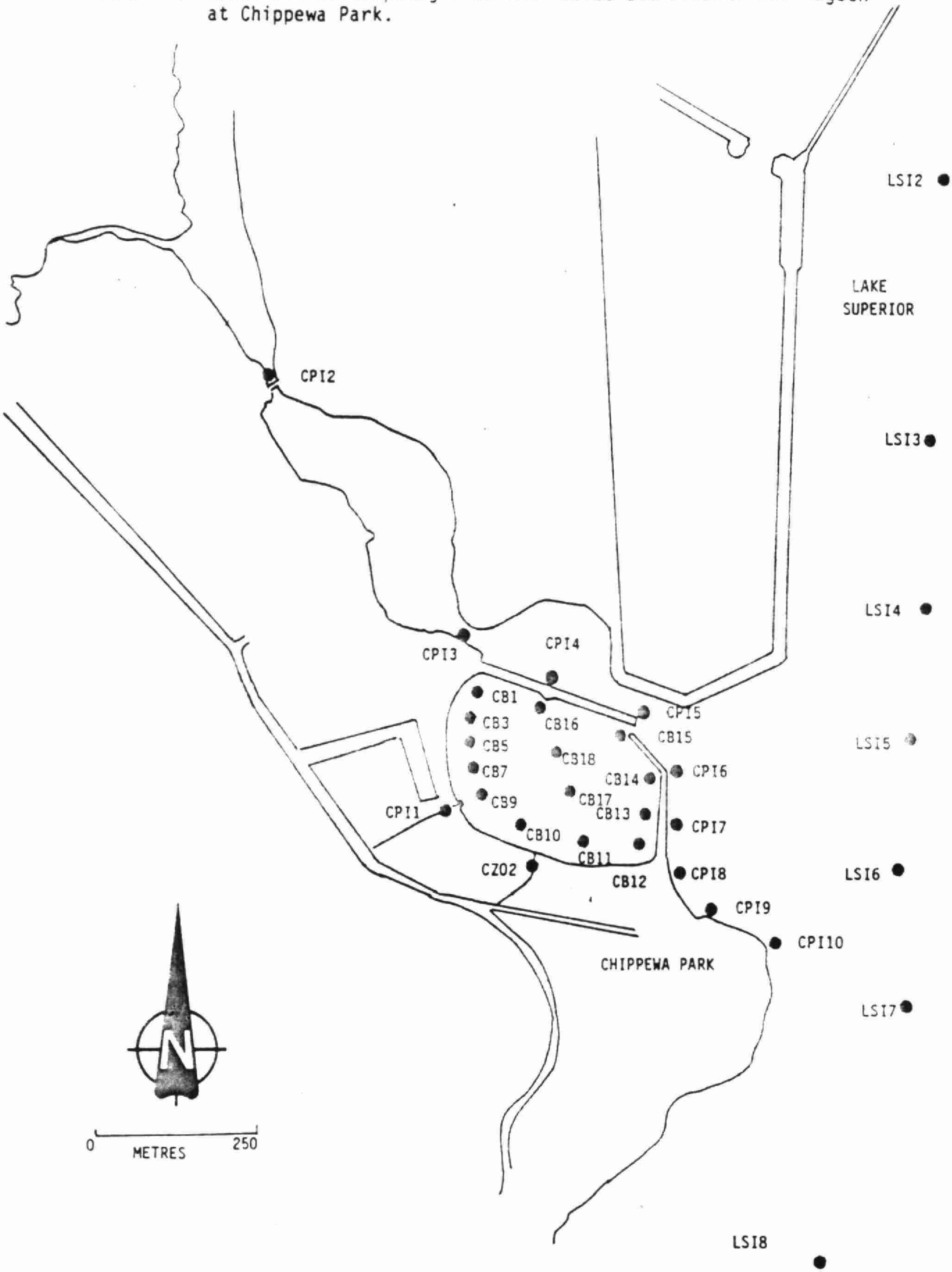
CB1 Extreme left side of bathing area
CB3 Left side
CB5 Middle left side
CB7 Middle right side
CB9 Right side, out from wharf
CB10 Off stream from zoo
CB11 Mid point between breakwater and stream from zoo
CB12 At base of breakwater

3. LAGOON STATIONS

(a) CHIPPEWA LAGOON

CB13 Off breakwater, mid point or short section of breakwater
CB14 Off breakwater, at bend
CB15 Off breakwater at end
CB16 Off boundary wharf, at mid point
CB17 Middle of lagoon, north side
CB18 Middle of lagoon, south side

FIGURE 2. Locations of sampling stations inside and outside the lagoon at Chippewa Park.



II. BACTERIOLOGICAL MONITORING

1. PARAMETERS

The following bacteriological parameters were used in the Chippewa Beach Joint Study.

TEST CODE	TEST DESCRIPTION	TEST METHOD
TCMF	Total coliform MF	m-endo LES agar
TCMFBK	TC background MF	m-endo LES agar
FCMF	Fecal coliform MF	m-TEC agar
FCMFBK	FC background MF	m-TEC agar
ECMF	E. coli MF	m-TEC-IG agar
ECMFBK	EC background MF	m-TEC-IG agar

2. SAMPLING FREQUENCY

Bacteriological samples were collected each morning, 5 days per week from the second week of June to the last week of August.

3. SAMPLE HANDLING

Bacteriological samples were placed on ice immediately after collection and returned to the laboratory for analysis within 2 hours of collection. In the laboratory, samples were analyzed within 2 hours of receipt.

III. METEOROLOGICAL AND PHYSICAL/CHEMICAL MONITORING

1. PARAMETERS

(a) Meteorological

Rainfall
Wind intensity
Cloud cover
Wind direction

(b) Physical

Water temperature
Sample collection time
Wave action
Bather load in bathing area
Presence of waterfowl and other wildlife

(c) Chemical

Turbidity

2. SAMPLING/MONITORING FREQUENCY

(a) Meteorological

A rain gauge was set up in the maintenance area at Chippewa Park and monitored on a daily basis. Each morning, between 8 and 9 a.m., the amount of precipitation collected in the rain gauge over the previous 24 hours was measured and recorded. Other meteorological conditions were monitored at the time of sample collection at each beach.

(b) Physical

The physical conditions were monitored at each beach on the days that water samples were collected.

(c) Chemical

Initially, turbidity was monitored at each sampling station. Later in the summer, however, once the average turbidity levels had been determined, only selected stations continued to be monitored for turbidity.

IV. DATA REPORTING

All bacteriological and other data were reported to the Thunder Bay District Health Unit. On those sampling days when the fecal coliform counts in the bathing area were elevated above 100 per 100 ml., the counts were notified to the Health Unit by telephone.

V. BEACH PLACARDING

The decision to placard the bathing area at Chippewa Beach was the sole responsibility of the Medical Officer of Health. Once notified, the City of Thunder Bay was responsible for the erection of the placards.

VI. DATA ANALYSIS

Summaries of the bacteriological and other data were prepared. Prior to statistical manipulation, the bacterial data was log transformed. A one-way analysis of variance (ANOVA) was performed on the transformed data. This analysis allowed the sampling stations to be grouped into homogenous groups that were statistically identical. The 't-test' was then used to identify the stations that were statistically different from each other.

RESULTS AND DISCUSSION

Water sampling was initiated in the bathing area and adjacent land locations at Chippewa Park on the June 7, 1988 and continued until August 26, 1988. These stations were sampled on 55 separate days. Stations located in Lake Superior were sampled approximately 33 times, beginning on June 8, 1988 and continuing until August 19, 1988. The number of samples from Lake Superior was lower because high waves often prevented their collection.

The results of the Chippewa Joint Beach Study will be discussed under seven main headings:

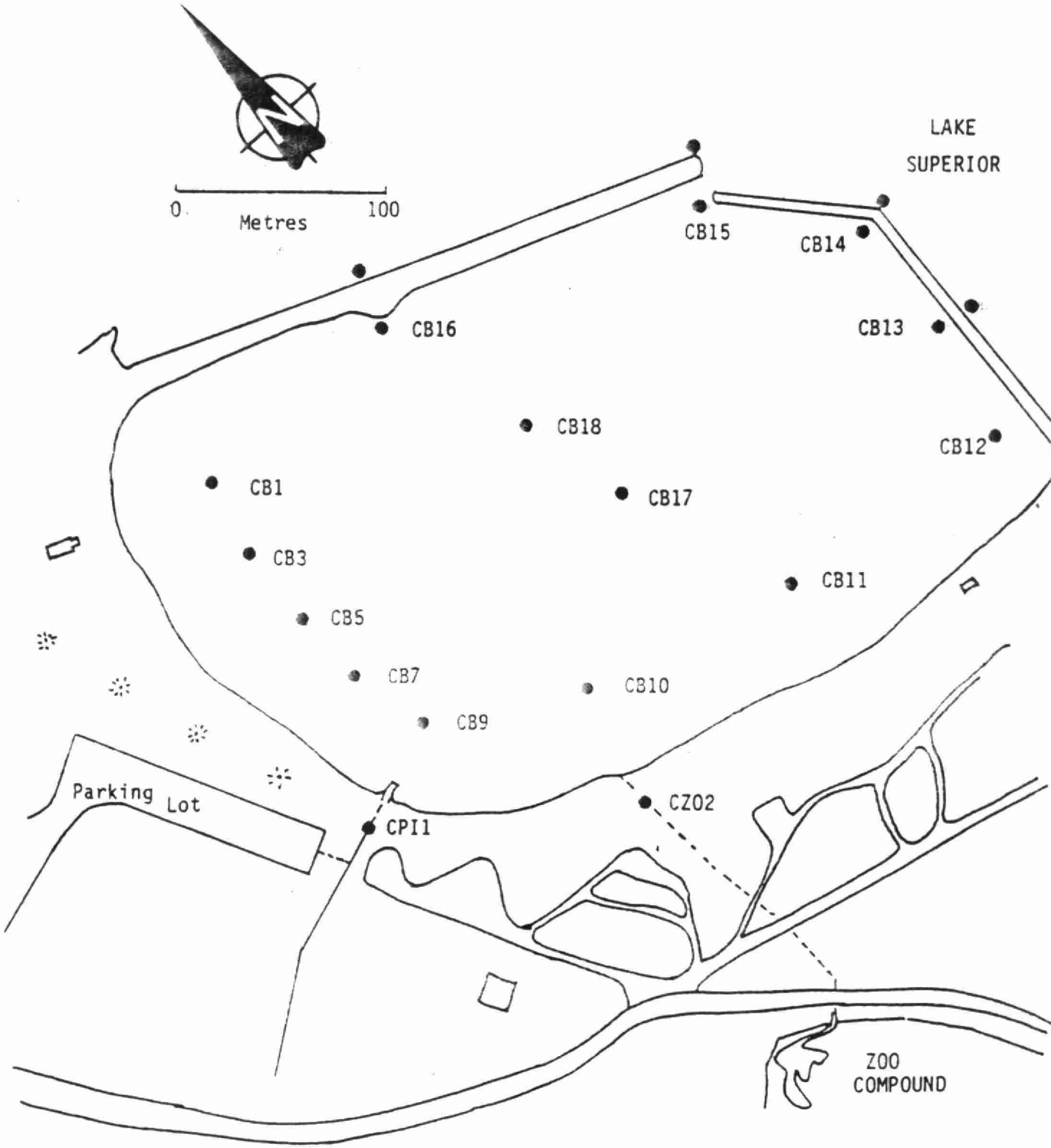
I. Definition of the Bathing Area
II. Homogeneity of Sampling Stations
III. External versus Local Sources of Fecal Contaminants
IV. Factors Affecting The Bacterial Levels in Bathing Area
V. Local Sources of Fecal Coliforms
VI. Relationship Between Turbidity and Bacterial Levels
VII. Public Health Considerations

I. DEFINITION OF BATHING AREA

For the purposes of this study, the bathing area was defined as an area that extended from the extreme left side of the beach around to the base of the breakwater and some 30-40 metres out into the lagoon. This definition was required as the lagoon was so shallow that, potentially, the entire lagoon could be considered bathing area.

The bathing area outlined in the above definition included stations CB1 to CB12 (see map Figure 3). This definition fit very well with observations made of bather activities at this beach. Few bathers were ever observed to go beyond 50-60 metres from shore. In fact, most of the bathing activities at Chippewa Beach took place close to shore with the bathers being grouped primarily between stations CB1 and CB9. This is the part of the beach that is the closest to the swings and slides. Very few bathers were observed to use the bathing area between stations CB9 and CB12.

FIGURE 3. Locations of sampling stations inside the lagoon at Chippewa Park.



II. HOMOGENEITY OF SAMPLING STATIONS

Stations within a single, homogeneous group tend to be affected by one or more common factors, otherwise their data would not be similar. Stations from different groups are affected either by different factors, or by differing degrees of common factors. In this study, it was important to determine whether or not groups of stations had statistically similar data and, therefore, were being affected by the same factors.

The data from the stations located in the bathing area, the lagoon, inside and outside the breakwater, and Lake Superior were all tested by analysis of variance (ANOVA) to determine if they were statistically the same. Stations that had statistically similar data were then placed into groups that were both statistically and geographically homogeneous. In other words, if stations had similar data and were located in a area where they could be logically grouped together, they were placed in the same group.

1. BATHING AREA SAMPLING STATIONS

The fecal coliform data from the 8 bathing area stations (CB1 to CB12) were tested by ANOVA to see if they formed a single, homogeneous group. It was found that the bathing area stations could be separated into two distinct groups that were statistically and geographically different from each other (See map, Figure 3). Stations CB1, CB3, CB5, CB7 and CB9 formed one group and stations CB10, CB11, and CB12 formed a second group.

The fecal coliform geometric means for individual stations and for the two groups of stations are shown in Table 1. The mean for the first group was 89. The mean for the second group was 43. The geometric mean for the first group of bathing area stations was twice as high as the second group. Clearly, these two groups of bathing area stations were being affected differently by the physical and meteorological factors in the Park.

Based on the difference observed in the bacterial data and the fact that a greater number of bathers used one section of the beach more than the other, in this report, these two sections will be called the 'primary' and 'secondary' bathing areas. The primary bathing area includes stations CB1 to CB9. The secondary bathing area includes stations CB10 to

CB12. Because of its greater usage, the primary bathing area was chosen to form the baseline dataset for all comparisons between bathing area and non-bathing area stations.

TABLE 1. Geometric mean fecal coliform levels of the two groups of bathing area stations at Chippewa Beach.

GROUP 1 STATIONS		GROUP 2 STATIONS	
Station #	Fecal Coliforms (G.M./ 100 ml)	Station #	Fecal Coliforms (G.M./ 100 ml)
CB1	93	CB10	54
CB3	93	CB11	38
CB5	75	CB12	39
CB7	83		
CB9	104		
GROUP G.M.	89		43

2. LAGOON AREA STATIONS

The fecal coliform data from all the stations in the lagoon were also tested by ANOVA to determine groupings. The stations in this comparison included both the bathing area and non-bathing area. The non-bathing area stations included the three stations along the inside of the breakwater (CB13, CB14, and CB15), one station at the edge of the wharf (CB16), and the two stations located in the middle of the lagoon (CB17 and CB18). (See map Figure 3).

It was found that the stations in the lagoon could be placed into three distinct groupings that were significantly different from each other. The first group was composed of the 5 stations (CB1-CB9) in the primary bathing area. This group had the highest fecal coliform levels of all the groups (overall mean of 89). The second group was composed of the 3 stations (CB10-CB12) in the secondary bathing area. This group had the next highest level of fecal coliforms (overall mean of 43). Finally, the third group was composed of the 5 stations in the non-bathing area of the lagoon. This group had the lowest levels of fecal coliforms. The geometric mean for the lagoon group of stations was 26.

The differences found between the group of non-bathing area stations in the lagoon and the two groups of bathing area stations indicates, as before, that these three groups of stations were being affected differently by the physical and environmental factors at the Park.

3. BREAKWATER SAMPLING STATIONS

Fecal coliform data from stations located just inside the breakwater (CB13, CB14 and CB15) were compared to that from stations located just outside the breakwater (CPI6, CPI7,CPI8, CPI9, and CPI10) (See map, Figure 2). The data were analyzed in an identical fashion to that used for the lagoon stations and are shown in Table 2.

The geometric mean of the group of stations inside the breakwater was 25. The geometric mean of the group of stations outside the breakwater was 23.

There was no significant difference in the fecal coliform data between the two groups of stations. In other words, the bacterial water quality on both sides of the breakwater was virtually identical.

TABLE 2. Geometric mean fecal coliform levels of several groups of non-bathing area stations at Chippewa Park.

LAGOON		INSIDE BREAKWATER		OUTSIDE BREAKWATER		L. SUPERIOR	
#	FC	#	FC	#	FC	#	FC
CB13	26	CB13	26	CPI6	26	LSI5	20
CB14	28	CB14	28	CPI7	18	LSI6	21
CB15	22	CB15	22	CPI8	23	LSI7	15
CB16	32			CPI9	26		
CB17	23			CPI10	22		
CB18	26						
GROUP	26		25		23		18

4. LAKE SUPERIOR SAMPLING STATIONS

Fecal coliform data from stations located just outside the breakwater (CPI6 to CPI10) were compared to that from stations located further out in Lake Superior (LSI5, LSI6, and LSI7). (See map, Figure 2). This data is also shown in Table 2.

The geometric mean for the group of stations in Lake Superior was 18. Although this number is lower than that for the group of stations located just outside the breakwater, there was no significant difference between these two groups of stations.

III. EXTERNAL VS LOCAL SOURCES OF FECAL CONTAMINANTS

When bacterial contaminants are found in a receiving water, there are several techniques that may be used to determine the location of the bacterial source. These may include the following:

- Bacterial gradients
- Concurrence of peaks
- Travel time
- Ratios of bacterial types
- Specific indicator groups

Several of these methods were employed in this study to determine the source of the fecal bacterial contaminants found in the bathing area at Chippewa Beach.

1. BACTERIAL GRADIENTS

First, a digression to explain some terminology about sources of bacterial contaminants, receiving bodies of water and the relationship between the two. A source of bacterial contaminants can be described either as a point source or non-point source. An example of a point source is a single pipe from an industry. An example of a non-point source is agricultural land along a river or cottages along a shoreline. A receiving body of water is the water body that the contaminants are put into. This could be a river, bay, lake, etc.

Bacterial contaminants in a receiving body of water will, in general, react in a specific manner. As the contaminants spread out from the source into the receiving water, their numbers will get lower and lower as the distance from the source increases. This is caused, not only by the diluting effect of the receiving water on the source as it spreads out, but also by the die-off of the bacteria as they are carried away from the source by the currents and, finally, by the bacteria settling out of the water column into the sediments below.

These three factors will produce a gradient (or slope) in the average levels of bacteria observed at each sampling station (or groups of sampling stations). Generally, the bacterial numbers will be highest at the source and lowest in the receiving water at the sampling stations furthest away from the source. As the distance from the source increases, the levels of bacteria will go down. The direction that this gradient runs can be used to indicate the

direction from which the contaminants are most likely to have traveled.

Now, back to the case at hand. If the bacterial contaminants in the primary bathing area at Chippewa Park were coming from external sources outside the Park, they would have to come from the source via Lake Superior. Then, they would have to pass through the opening at the end of the breakwater, or through the breakwater itself, cross the lagoon and, finally, enter the primary bathing area (See map, Figure 3). If this was the case, there should be a gradient in the bacterial data that should show the highest bacterial levels at the source, lower levels in Lake Superior, still lower levels in mid-lagoon, and the lowest levels in the primary bathing area.

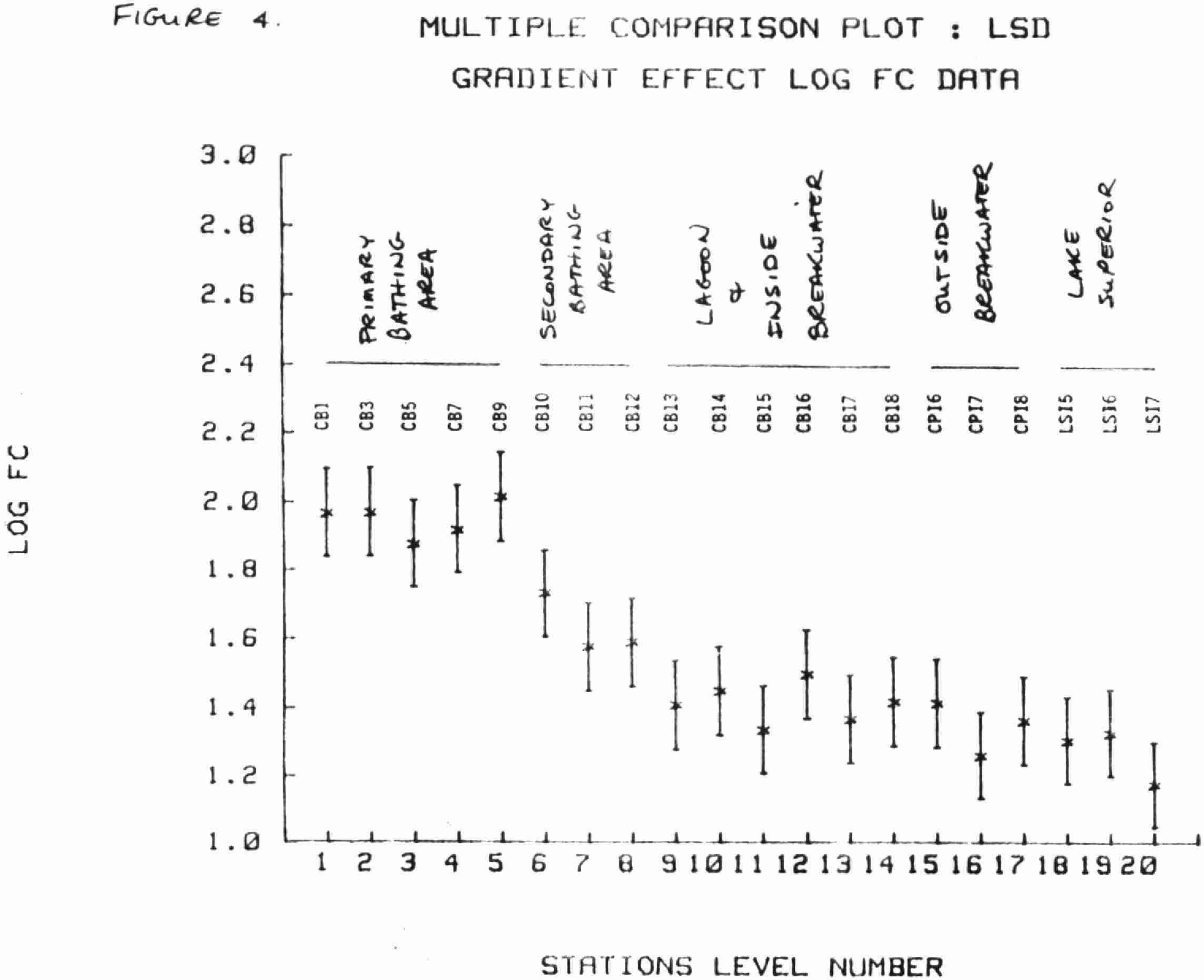
Alternatively, if local sources were causing the contamination, the gradient should show the highest bacterial levels in the bathing area, lower levels in mid-lagoon, and still lower levels in L. Superior (unless a baseline level had been reached before this).

Therefore, with the prospect of observing a gradient in the data, the geometric mean fecal coliform levels of specific groups of stations were compared. This included the group of 5 sampling stations located in the primary bathing area, the group of 3 stations in the secondary bathing area, the 2 stations located in the middle of the lagoon, the 3 stations located just inside the breakwater, the 5 stations located outside the breakwater and the 3 stations in Lake Superior located 200 metres outside the breakwater. This data is shown in Table 3.

TABLE 3. Geometric mean fecal coliform levels of various groups of stations relative to the distance from the primary bathing area.

SAMPLING STATION GROUP	STATIONS IN GROUP	G.M. FECAL COLIFORMS PER 100 ML
Primary bathing area	CB1,CB3,CB5,CB7,CB9	89
Secondary bathing area	CB10,CB11,CB12	43
Middle of lagoon	CB17,CB18	25
Inside breakwater	CB13,CB14,CB15	25
Outside breakwater	CPI6,CPI7,CPI8,CPI9,CPI10	23
L. Superior	LSI5,LSI6,LSI7	18

FIGURE 4.


MULTIPLE COMPARISON PLOT : LSD
GRADIENT EFFECT LOG FC DATA
LOG FC
3.0
2.8
2.6
2.4
2.2
2.0
1.8
1.6
1.4
1.2
1.0
PRIMARY BATHING AREA
SECONDARY BATHING AREA
LAGOON & INSIDE BREAKWATER
OUTSIDE BREAKWATER
LAKE SUPERIOR
CB1
CB3
CB5
CB7
CB9
CB10
CB11
CB12
CB13
CB14
CB15
CB16
CB17
CB18
CP16
CP17
CP18
LS15
LS16
LS17
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
STATIONS LEVEL NUMBER

As shown in Table 3, the mean fecal coliform level at each group of sampling stations declined as the distance from the primary bathing area increased. Within the lagoon, there was a distinct gradient in the fecal coliform data. The gradient started at a high level at the 5 stations in the primary bathing area and then dropped to a lower level in the secondary bathing area. The level in the middle of the lagoon was even lower. This level remained the same at the stations inside the breakwater and then declined slightly outside the breakwater. The slow decline continued out into Lake Superior.

The gradient or slope in the fecal coliform data can also be shown by plotting the fecal coliform data for the individual stations located inside and outside the lagoon. This data is shown in Figure 4. This is a least significant differences (LSD) plot whereby the means of the log values for fecal coliforms at each station are plotted (shown by an 'x'). The confidence limits about the mean value is shown by a bar.

As the distance from the primary bathing area increased, the average level of fecal coliforms at each station declined. The slope of this gradient indicated that the fecal coliform bacteria in the bathing area were coming from the direction of the beach, not from the direction of Lake Superior. Therefore, the contamination of the bathing area at Chippewa Beach was caused by local, not external, sources.

2. CONCURRENCE OF BACTERIAL PEAKS

A second factor that can be examined in the study of bacterial sources, is concurrence of bacterial peaks.

In monitoring the data from a source of bacteria such as a sewage treatment plant, there will often be a series values that, for a period of time, are higher than average. These are peaks in the bacterial data. The peaks that are observed in the source will also be present in the data at the stations in the receiving water. However, the size of the peaks in the receiving water will usually be reduced and an allowance must be made for time of travel. In other words, the peaks at the stations in the receiving water should concur with the peaks in the source water.

(a) External Sources

The potential for an external source to contaminate the primary bathing area was examined. The four stations in Lake Superior that were adjacent to the lagoon, LSI4, LSI5, LSI6 and LSI7, were selected to represent the source since all contaminants from sources beyond these stations would have to flow past this group to reach the lagoon and hence, the bathing area. Peaks in this group of stations would have resulted from peaks produced elsewhere (e.g. the Kaministikwia River system).

Unfortunately, there were few significant peaks in the average daily fecal coliform levels at the four Lake Superior stations. Therefore, it was almost impossible to compare the peaks at these four stations with the occurrence of peaks in the primary bathing area. The overall average level of fecal coliforms for this group of four stations was 19 per 100 ml, while the highest daily average was only 96. Compared to the peaks in the bathing area which went as high as 5000 on one occasion and over 200 at least 12 times, the levels in Lake Superior were insignificant.

However, the total coliform levels at these Lake Superior stations were substantially higher than the fecal coliform levels. Therefore, this data was used instead of the fecal coliform data to look for the concurrence of peaks in the bathing area.

The overall average total coliform level at the four Lake Superior stations was 1726 per 100 ml. Consistently high levels were found in mid-June and mid-July. Much lower levels were observed in August.

In the primary bathing area, the overall average level of total coliforms was 342. This was substantially less than that observed at the group of four Lake Superior stations. Total coliform levels in the bathing area went up and down without any particular pattern that could be related to the group of stations in Lake Superior. Nevertheless, in the bathing area there were more high levels of total coliforms in August than in June or July - the exact opposite of the pattern found at the Lake Superior stations.

Thus, there appeared to be little, if any, concurrence of high bacterial levels in the bathing area with high levels at the Lake Superior stations. For example, for a five-day period in mid-July, from July 18 to July 22, high levels of total coliforms were found at the Lake Superior stations. No corresponding high levels were found in the bathing area. In fact, the levels in the bathing area during that time period were below average.

The lack of concurrence between these two groups of stations for both the total coliform and fecal coliform bacteria, indicates that the bacterial contamination of the bathing area by external sources is extremely remote.

(b) Local Sources

To examine the potential for local sources to contaminate the bathing area, station CPI1, the ditch crossing the playing field, was selected as an example of a local source for comparison to the primary bathing area. Peaks in the fecal coliform level at this source should produce concurrent peaks in the bathing area.

As noted earlier, the fecal coliform level in the bathing area tended to be low during June and July and high during August. This pattern corresponded almost identically to that observed at CPI1. During June and July, the fecal coliform levels in this small stream were either very low or there was no flow at all. However, in August, the flows increased and the fecal coliform levels also increased.

Thus, the high fecal coliform levels in the bathing area were found to be concurrent with high levels and high flow rates observed at one of the local sources. The concurrence of the bacterial peaks indicated the high probability that the fecal bacterial contamination of the primary bathing area was caused by local sources.

3. TIME OF TRAVEL FROM SOURCE

One further element in examining the sources of bacteria in a water body, is time of travel. This refers to the time required for any one bacterium to travel from the source to a given point in the receiving water.

At Chippewa Beach, if the sources of the bacterial contaminants of the primary bathing area were external, there would be a substantial amount of time required for these contaminants to travel from the source to the bathing area. However, if the sources of the contaminants were local, the travel time would be very short. A peak in the bacterial level at the local source should immediately produce a corresponding peak in the bathing area.

Time of travel can best be observed by examining the bacterial peaks at the source and monitoring the time required before those peaks are observed in the bathing area.

(a) External Sources

Unfortunately, the time of travel for the fecal bacteria from external sources could not be determined because, as we have noted above, the gradients for the external sources sloped the wrong way and there was no concurrence of peaks between the external sources and the bathing area.

(b) Local Sources

Time of travel for local sources, however, was relatively easy to determine. Peaks at CPI1 produced peaks in the bathing area on the same day. Thus, travel time to the bathing area was very short.

This result indicated that the fecal bacterial contamination of the primary bathing area at Chippewa Beach was caused by a local source.

In summary, the three methods: gradients, concurrence of peaks and time of travel, all indicated that the source of the fecal bacterial contamination at Chippewa Beach was arising from local sources and local sources only.

IV. FACTORS AFFECTING THE BACTERIAL LEVELS IN THE BATHING AREA

In the previous section, it was determined that the fecal bacterial contamination of the bathing area at Chippewa Beach was caused by local sources that were present at the Park. This is the same conclusion that was reached in the 1985 study.

Nevertheless, initially, in the 1988 study, as in the 1985 study, the local sources of the fecal coliform contamination of the bathing area were not particularly obvious. For example, a pipe spewing raw sewage was not present in the lagoon close to the bathing area. Because the sources were not readily obvious, and there was little data that related the contamination in the bathing area directly to a specific source, the local sources of fecal coliforms were determined indirectly.

The first step in this process was to list all the geometric mean fecal coliform data for the bathing area stations. This provided both the periods when the fecal coliform levels were low and the periods when they exceeded 100 per 100 ml. Then, the factors that influenced these levels were examined.

During the sampling period of June 7 to August 26, 1988, the daily fecal coliform geometric mean of the 5 bathing area stations (CB1-CB9) exceeded 100 per 100 ml on 21 of the 55 days that samples were collected (Table 4). Four of these peaks occurred in June, 3 occurred in July and 14 occurred in August.

1. METEOROLOGICAL CONDITIONS

The low number of peaks in both June and July, and the high number of peaks in August, were tied closely to the pattern of weather events during those months. The summer of 1988 was warmer than normal. All three months recorded higher than normal mean monthly temperatures (Table 5). Both June and July recorded one of the highest mean temperatures for the past 10 years. The total hours of sunshine for June was well above normal, about normal for July, and below normal for August. The total monthly rainfall for June was less than half of normal. Rainfall for July was only about 75% of normal. However, the rainfall for August was the highest monthly level ever recorded at Thunder Bay.

TABLE 4. FECAL COLIFORM GEOMETRIC MEAN LEVELS IN THE PRIMARY BATHING AREA AT CHIPPEWA BEACH.

ALL DATA

Jun 7/88 TO Aug 26/88

SAMPLING DATE YY MM DD	SAMPLING TIME	FECAL COLIFORM (FCMF) COUNTS PER 100 ML BEACH STATION NUMBERS CB1	CB3	CB5	CB7	CB9	DAILY GEOM MEAN
88 6 7	1:00	480	370	70	20	260	145
88 6 8	9:20	80	330	60	110	280	137
88 6 9	1:30	< 10	20	10	< 10	10	9
88 6 10	8:45	30	< 10	< 10	20	40	14
88 6 11							
88 6 12							
88 6 13	1:50	60	270	350	20	30	81
88 6 14	11:30	600	730	1000	380	1100	712
88 6 15	10:05	170	130	180	220	30	121
88 6 16	10:00	30	70	50	10	50	35
88 6 17	10:15	50	30	< 10	20	10	17
88 6 18							
88 6 19							
88 6 20	10:00	10	60	50	80	140	51
88 6 21	9:55	90	30	30	30	30	37
88 6 22	10:00	100	30	30	< 10	10	21
88 6 23	9:45	80	40	10	90	60	44
88 6 24	9:45	< 100	< 100	< 100	< 100	< 100	50
88 6 25							
88 6 26							
88 6 27	9:45	10	10	10	20	< 10	10
88 6 28	9:50	20	10	20	10	< 10	11
88 6 29	9:45	20	30	20	10	20	19
88 6 30							
88 7 1							
88 7 2							
88 7 3							
88 7 4	9:45	50	30	40	10	< 10	20
88 7 5	9:45	20	20	10	10	10	13
88 7 6	9:30	30	30	40	70	40	40
88 7 7	9:30	30	20	10	20	40	22
88 7 8	9:35	< 10	10	30	100	130	29
88 7 9							
88 7 10							
88 7 11	9:20	110	30	40	< 10	130	39
88 7 12	9:35	60	230	130	20	30	64
88 7 13	11:10	1000	90	140	680	350	313
88 7 14	9:45	80	90	70	80	180	94
88 7 15	9:50	10	60	130	30	700	70
88 7 16							
88 7 17							
88 7 18	9:45	10	30	30	40	30	26
88 7 19	9:40	160	40	50	230	280	116
88 7 20	9:45	50	60	40	60	40	49

TABLE 4. FECAL COLIFORM GEOMETRIC MEAN LEVELS IN THE PRIMARY BATHING AREA AT CHIPPEWA BEACH.

ALL DATA — Jun 7/88 TO Aug 26/88

SAMPLING DATE YY MM DD	TIME	CB1	CB3	CB5	CB7	CB9	DAILY GEOM. MEAN
		FECAL COLIFORM (FCMF) COUNTS PER 100 ML — BEACH STATION NUMBERS					
88 7 21	9:45	60	60	40	110	10	44
88 7 22	9:45	40	50	20	30	100	41
88 7 23							
88 7 24							
88 7 25	9:45	30	50	50	80	90	56
88 7 26	9:50	130	20	20	50	30	38
88 7 27	9:40	40	60	30	130	40	52
88 7 28	10:00	70	120	110	120	280	125
88 7 29							
88 7 30							
88 7 31							
88 8 1							
88 8 2	9:50	590	2700	1300	240	6000	1244
88 8 3	9:50	650	1000	840	1300	720	874
88 8 4	9:55	340	90	170	170	90	151
88 8 5	9:45	50	50	70	70	90	64
88 8 6							
88 8 7							
88 8 8	9:55	140	200	90	110	540	172
88 8 9	10:05	110	100	30	170	110	91
88 8 10	9:50	90	30	10	70	20	33
88 8 11	9:55	110	70	10	70	90	55
88 8 12	9:50	40	60	40	70	20	42
88 8 13							
88 8 14							
88 8 15	9:45	2000	2600	2100	1400	1500	1871
88 8 16	10:05	390	350	210	390	380	335
88 8 17	9:50	2300	1500	710	1100	4200	1625
88 8 18	9:45	590	700	650	500	410	560
88 8 19	9:40	130	60	130	240	140	128
88 8 20							
88 8 21							
88 8 22	9:45	60	120	110	90	220	109
88 8 23	9:50	700	1900	3300	1600	1200	1532
88 8 24	9:50	4700	3100	6200	5700	7400	5202
88 8 25	8:10	1100	800	2900	2800	2600	1794
88 8 26	9:45	360	530	530	490	830	528
GEOM. MEAN		93	93	75	83	104	

SEASONAL GEOMETRIC MEAN: 89

Thus, June, 1988, could be described as warm and dry, July as hot and relatively dry, while August was warm and extremely wet.

The hot, dry weather did not appear to contribute to the peaks in bacterial levels at Chippewa Beach, as the fecal coliform levels were relatively low for both June and July. High temperatures had been suggested as one of the factors that influenced the bacterial levels at Chippewa Beach in other years. In 1988, the hot weather itself did not lead to high bacterial levels in the bathing area.

TABLE 5. Comparison of meteorological conditions for the months of **June, July and August, 1988.**

METEOROLOGICAL CONDITION	JUNE	JULY	AUGUST
Mean Monthly Temperature			
1988	16.0	19.4	17.6
Normal	14.0	17.6	16.4
Total hours of Sunshine			
1988	302.9	309.7	214.5
Normal	262.0	303.7	255.9
Total Monthly Rainfall			
1988	32.1	56.1	170.4
Normal	76.7	75.4	83.1

From an examination of Table 4, it was found that there was a direct relationship between the occurrence of high fecal coliform levels in the bathing area and heavy rainfall. A similar relationship was found with the occurrence of high waves. Both of these factors caused the fecal coliform bacterial levels to rise in the bathing area.

2. RAINFALL AND STORMWATER RUNOFF

By itself, heavy rainfall does not cause the fecal coliform bacterial contamination of a water body. However, heavy rainfall usually leads to stormwater runoff. Stormwater runoff occurs when rainfall that

is not absorbed by the ground, runs over the surface of the ground into a receiving body of water. In the process of flowing over the ground, the stormwater runoff picks up a variety of contaminants and flushes these into the receiving water. At Chippewa Park, stormwater runoff entered the bathing area at two specific points (the two ditches, CPI1 and CZO2) and a multitude of non-specific points (all along the beach).

(a) Runoff from Ditch Crossing Playing Field

The ditch crossing the playing field drains not only the playing field area but also the woodlands across the road and the unpaved parking lot in front of the primary bathing area. It was found that the fecal bacterial levels of the water in this ditch varied substantially throughout the summer, usually in direct response to the effects of stormwater runoff.

In June, when there was relatively little rainfall, the flow of water was low and the water in the ditch was clear (the turbidity was less than 5 F.T.U.). The fecal bacterial levels were also low, often being less than 10 per 100 ml. In July, with the exception of one day, the water had dried up due to the lack of rainfall. Therefore, there was no flow of water in the ditch as, and hence no fecal coliforms from this location. In August, water started flowing again in th ditch in response to the increased rainfall. At times in August, the levels of fecal coliform bacteria in this ditch were extremely high.

An example of the impact of stormwater runoff on the water quality of this ditch was clearly demonstrated on August 2, 1988. On that day, a short, intense rainfall occurred just before the ditch at CPI1 was sampled. At that time, it was observed that a large quantity of muddy runoff water was flowing downhill over the unpaved parking lot which is in front of the primary bathing area. This water was draining into the ditch via the manhole at the south end of the parking lot. The water in the ditch was so turbid as a result of the muddy water coming from the parking lot, that the turbidity level of the sample was too high to measure (higher than 400 F.T.U.). Normally, the water in this ditch had a turbidity of less than 10. The fecal coliform level in this sample was also extremely high (45,000 per 100 ml). This was

the highest level for turbidity and fecal coliforms recorded at this location for the summer. Unfortunately, this was the only time during the summer that this ditch was sampled directly following a heavy rainfall. Nevertheless, this one instance showed the dramatic effect of stormwater runoff on the water quality in this ditch.

It was noted that the levels of fecal coliform bacteria in the sample collected from the ditch were influenced directly by time of sampling. If the sample was collected <u>immediately</u> following a heavy rain, while the flow was still high and the water was turbid, the fecal coliform level was high. Alternatively, if the sample was collected some time <u>after</u> the rainfall (i.e. the rainfall occurred during the previous afternoon or evening), the fecal coliform level was much lower even though the quantities of rain that fell in both of these situations were similar. Thus, the fecal coliform levels contributed to the bathing area by this ditch were probably underestimated.

The outfall from this ditch flowed directly into the bathing area close to station CB9. Of the five stations in the primary bathing area, station CB9 had the highest average turbidity and fecal coliform levels. These elevated levels were caused primarily by the outfall from this ditch.

At times, a zone of muddy water extended out from the ditch into the bathing area near station CB9. On June 14, following a short, heavy rainfall, this zone of muddy water was visible from shore. At the time that samples were being collected from the bathing area stations, this muddy water had not yet reached the other nearby stations in the bathing area.

The turbidity level at station CB9 was 102 F.T.U. However, the turbidity at the two nearby stations, CB7 and CB10, was only 15 and 11, respectively. This zone of muddy water around CB9 also affected the fecal coliform level. On June 14, in this zone, the fecal coliform level at CB9 was 6000. This was significantly higher than the levels at CB7 and CB10 whose levels were only 350 and 150, respectively.

(b) Runoff from the Sand Beach

Substantial quantities of stormwater runoff also entered the bathing area directly from the beach itself. This was evidenced by a large number of deep fissures that were observed in the sand following a heavy rain. The heavy rainfall had caused the sand beach to be eroded. This water flowed from the sand beach on a broad front directly into the bathing area. This caused, not only an increase in the turbidity of the water in the bathing area, as this stormwater was always muddy, but also, an increase in the level of fecal coliform bacteria.

The impact of stormwater runoff on the bacterial water quality of the bathing area can be seen in Table 6. This table lists only those dates when a rainfall of about 10 mm or more was recorded at Chippewa Park. (Note: 10 mm of rainfall was used as values less than this did not tend to generate stormwater runoff). The geometric mean fecal coliform levels for the five stations in the primary bathing area before and after each rainfall event are listed.

TABLE 6. Relationship between rainfall and the fecal coliform levels in the primary bathing area.

DATE	RAINFALL (mm)	G.M. FECAL COLIFORM LEVEL	
		BEFORE RAIN	AFTER RAIN
June 14	15.4	81	712
July 13	9.4	64	313
August 5	14.8	151	64
August 8	10.8	64	172
August 14	48.7	42	1871
August 17	22.0	335	1625
August 23	23.3	109	1532
August 24	37.4	1532	5202

The 'before' levels of fecal coliforms were those levels that were recorded prior to the rainfall. Usually, this was the previous day's value but on several instances when no samples were collected on the previous day, the value used was the most recent available (2 or 3 days) prior to the rainfall. Similarly, the 'after' value was the value recorded on the day that the rainfall occurred. However, if no samples were collected on that day, the value used was from the next available sampling time. For example, the 'after' value shown for August 14 was actually sampled on August 15. It is probable that this result would have been much higher (since this was an extremely heavy rainfall), if the sample had been taken on August 14.

On all but one occasion, the average fecal coliform level increased substantially following the rainfall (Table 6). This indicated a direct cause and effect relationship between rainfall (i.e. stormwater runoff) and fecal coliform level in the bathing area. The single exception to this relationship occurred on August 5 when the 'after' value was lower than the 'before' value. It appeared that this was caused by a light, but prolonged, rainfall during the afternoon and night of August 4 that produced a fairly large quantity of rainfall but little runoff as it was mostly absorbed by the ground and therefore, did not wash contaminants into the bathing area.

In several cases the 'before' fecal coliform values were quite high. This occurred when a second storm followed very close to the previous one and did not provide sufficient time for the bacteria to return to baseline levels.

3. WAVE ACTION

The second major factor that caused the fecal coliform levels in the bathing area to increase was the action of high waves. The high waves in the bathing area resulted in four things occurring:

(a) The high waves washed up on the beach and carried sand and other material within reach into the bathing area.

(b) The high waves broke apart any fecal material that may have been lying on the beach at the water's edge or in the shallow water in the bathing area.

(c) The high waves distributed this material and its associated bacteria throughout the bathing area by its constant mixing action.

(d) The high waves stirred up the sediments underlying the bathing area and resuspended the associated bacteria back into the water column of the bathing area.

The impact of high waves on the bacterial water quality of the bathing area at Chippewa Beach was clearly demonstrated on August 2, 1988. On that day, the wind was blowing from the east and north-east directions at a speed of about 26 km/hour with gusts to 33. Although, this is not a particularly high wind, it was generating waves on Lake Superior that were crashing against the breakwater. The direction of the wind permitted the waves to penetrate into the lagoon and roll up onto the beach.

The geometric mean fecal coliform level in the primary bathing area on that day was 1244 per 100 ml. The turbidity of the water in the bathing area was also elevated. The average turbidity that day was 32 F.T.U. Normally, the turbidity of the bathing area was only 5-10 F.T.U.

On days when the wind was from the east, the water level in the lagoon was usually higher than normal. On June 14, 1988, the water level in the lagoon was observed to be higher than normal. The high water level in the lagoon indicated that there had been some flow of water into the lagoon area from Lake Superior. This slight flow, combined with the high waves that were also occurring on June 14, should have provided a good opportunity for bacterial contaminants to be carried into the lagoon from Lake Superior.

However, on that day, the fecal coliform level in the primary bathing area compared to the level beside the breakwater were opposite to what might have been expected if this theory was correct. The fecal coliform level in the bathing area was 712. The level at the breakwater was only 16. This data did not support the contention that the bathing area was being contaminated by external sources even during periods of water flowing into the lagoon.

V. LOCAL SOURCES OF FECAL COLIFORMS

Once the factors that were influencing the high levels of fecal coliform bacteria in the bathing area were determined, the local sources of the fecal coliforms were more readily apparent. The fecal coliform levels in the bathing area rose following heavy rainfall and stormwater runoff. Therefore, the source of these bacteria must be on the surface of the ground for them to be carried by the stormwater into the bathing area. Similarly high waves also resulted in high levels of fecal coliforms in the bathing area. This indicated that the fecal coliforms must be present either in the sediments stirred up by the waves or at the waters edge.

At Chippewa Park, the fecal coliform levels in the stormwater runoff coming from the main parking lot and playing field area were high. For the levels to be high in this runoff, the source of the fecal coliforms must be present on the surface of the parking lot or on the surface of the ground in the adjacent area. In addition, the stormwater entering the bathing area after flowing over the sand beach contained high levels of fecal coliform bacteria. This indicated that a source of the fecal coliforms was present on the surface of the sand beach or on the adjacent ground.

A visual inspection of the parking lot did not reveal any unusual material that might contain fecal coliforms, only the occasional dropping from gulls or other birds. The sand beach, however, was different. On it, close to the waters edge and in the shallow water of the bathing area, a number of droppings from the flock of 25 Canada geese that inhabited the Park were observed.

This flock of Canada geese was a normal resident at Chippewa Park. Often the flock alternated between the ponds in the dredge disposal area north of the park and the park itself. In the park, the flock was often present near the water close to the campground beach. However, it was observed on numerous occasions either swimming on the lagoon or cropping the grass on the lawns in various places near the lagoon.

On August 10, when the droppings at the waters edge were observed, most of the droppings on the sand beach were still intact and could easily recognized. The droppings in the water had started to break apart.

Two of the droppings on the sand beach by the waters edge were collected for analysis. The results of this analysis are given in Table 7.

On August 10, when these samples were collected, there was no indication of the length of time that the droppings had been lying on the beach. Because these droppings may not have been fresh, the counts of bacteria may have either increased or decreased from the level when they were first eliminated. The fecal coliform levels in duck droppings are known to increase in counts shortly after elimination (3). This may also be the case with goose wastes. Nevertheless, regardless of whether or not the levels had increased or decreased, the levels that were found were the levels that would be available to contaminate the bathing area.

TABLE 7. Bacterial content of Canada geese droppings collected from the sand at Chippewa Beach, August 10, 1988.

DROPPINGS SAMPLE #	WEIGHT (gm.)	BACTERIAL COUNTS PER GRAM WET WEIGHT			
		TCMF	FCMF	ECMF	FSMF
1	8.82	1.6×10^{7}	8.7×10^{6}	5.2×10^{6}	4.0×10^{5}
2	9.55	2.8×10^{7}	2.0×10^{7}	1.5×10^{7}	1.1×10^{6}
Average	9.19	2.2×10^{7}	1.4×10^{7}	1.0×10^{7}	7.5×10^{5}
TOTAL / DROPPING		2.0×10^{8}	1.3×10^{8}	9.2×10^{7}	6.9×10^{6}

The number of fecal coliform bacteria in the droppings was found to be over 10 million per gram! Each of the droppings that was analyzed weighed about 10 grams each. If these droppings were mixed with water (as would happen with the action of waves on them), and distributed in the bathing area without any die-off of the bacteria or settling of the bacteria to the sediments, the total contribution of fecal coliforms in each dropping would be approximately 100 million!

Unfortunately, Canada geese are renowned for being inefficient processors of food and tend to eliminate large quantities of semi-digested waste. Canada geese have been estimated to eliminate some 250 grams of waste per day (4). If the 250 gram figure is correct, and allowing for

some desiccation of the droppings found on the beach, each goose would have eliminated some 15 to 20 times per day. Thus, the contribution of a single goose to the overall fecal coliform level at the park would be over 100 million per day and of the flock, in the billions.

These are terrifically high numbers. Fortunately, we know that not all of these bacteria, once dispersed in water, will survive, and most will quickly settle out, but in relation to the water quality guideline of 100 fecal coliforms per 100 ml, it is easy to see how the bathing area could be quickly contaminated by these wastes.

Canada geese were not the only waterfowl observed at the beach. Small flocks of ducks were also observed on a regular basis, both in the lagoon at Chippewa Park and outside the breakwater. A number of Great Blue Herons were also observed near station CPI3. In addition, flocks of gulls often rested on the sand beach in front of stations CB3 and CB5.

In a number of studies, these waterfowl have been shown to have a significant impact on the bacterial quality of water. Studies in Madison, Wisconsin (3), Chesapeake Bay, and elsewhere (5,6), have found that the bacterial water quality of a water body can be affected by waterfowl. Mallard ducks, for example can contribute daily fecal coliform counts equal to two humans (7). This could explain the elevated counts observed in the water coming from the duck ponds in the zoo via station CZO2.

In summary, the waterfowl at the park were the primary sources of the fecal coliform bacteria found in the bathing area at Chippewa Beach.

VI. RELATIONSHIP BETWEEN TURBIDITY AND BACTERIAL LEVELS

Following a heavy rainfall or high waves, the water in the area of the lagoon closest to shore usually became very turbid. This area of muddy or turbid water then gradually spread out into the bathing area and within 1 to 2 hours reached the locations of the bathing area sampling stations.

The zone of higher turbidity in the water could be easily seen from shore on some days. On June 13, 1988, stations CB3 and CB5 were observed to be inside the higher turbidity zone while stations CB1, CB7 and CB9 were outside the zone. It was found that samples collected outside the zone had lower turbidity and fecal coliform levels than those inside the zone. This data is shown in Table 8.

TABLE 8. Fecal coliform levels at stations in the bathing area inside and outside the zone of increased turbidity.

STATION #	TURBIDITY (F.T.U.)		FECAL COLIFORMS / 100 ML	
	Outside	Inside	Outside	Inside
CB1	13		60	
CB3		31		270
CB5		34		350
CB7	14		20	
CB9	10		30	
AVERAGE	12	32.5	37	310

The relationship between turbidity and fecal coliform level is clearly shown in this table. At those stations where the turbidity was higher, the fecal coliform counts were also higher. In fact, during the summer, the level of turbidity was used as a guide to determine how much the samples needed to be diluted prior to bacterial analysis.

At Chippewa Beach, it appeared that the turbidity of the water in the bathing area would be a useful tool for helping to determine the safety of the water for bathing. Turbidity, or cloudiness of the water, can be measured fairly easily. For example, during the summer of 1988, the person collecting the water samples, simply looked at the bottom to see if it was visible. On those days that it was not, the fecal coliform levels were expected to be high (and they always were).

This crude measurement had the advantage that it was available immediately. There was no need to wait for 24 hours while the bacterial analysis was being completed. Once the relationship between turbidity and fecal coliform levels in the bathing area at Chippewa Park had been clearly outlined, whenever the water was extremely turbid, it was known automatically that the bacterial counts were over the Provincial guideline.

This type of measurement could easily be employed by the park staff to indicate whether or not the fecal coliform counts in the bathing area were expected to be above or below the Provincial guideline. Then, when the water was very turbid, the bathing area could be placarded at a moments notice by the park staff. This would provide the bathers with a greater degree of protection than they currently enjoy. Water samples could be collected at the same time for confirmation, but the placards would already be up and the public protected.

VII. PUBLIC HEALTH CONSIDERATIONS

1. PLACARDING THE BATHING AREA

The bathing area at Chippewa Beach was placarded during two time periods in the summer of 1988. Placards warning of a potential health risk were erected at 1530 hours on Thursday, August 4, 1988. These placards were removed on the following Thursday, August 11, at 1600 hours. On Wednesday, August 17, 1988, placards were again erected at Chippewa Beach. These placards remained in place throughout the rest of August.

It was noted that the erection of placards at Chippewa Beach involved substantial delays from the time the sampler observed an event likely to result in elevated fecal coliform levels in the bathing area, to the time that placards were actually in place. For example, on Sunday morning, August 14, 1988, one of the heaviest rainfalls of the summer was recorded. The rainfall actually took place during the night of August 13 and the early morning of August 14. Since this took place during the weekend, the rainfall was recorded by park staff. No bacterial samples were collected until Monday, August 15. That day was warm and sunny, just perfect for swimming. However, the fecal coliform bacterial levels in the bathing area were over 1800 that day. No placards were in place to warn of this situation. Unfortunately, as is always the case, the analytical results were not available until the following day. Thus, the results for the bathing area samples collected on August 15 were not available until August 16. At that time, the M.O.E. laboratory notified the Thunder Bay District Health Unit who in turn requested the City to erect placards. The placards were erected by the parks staff sometime during the day on Wednesday, August 17.

No one was at fault in the delay in erecting the warning signs. However, if a system had been in place for the automatic erection of placards by park staff as soon as they recorded this very heavy rainfall, placards would have been in place on Sunday morning rather than on Wednesday and the public would not have been exposed to this risk.

2. LEVELS OF E. COLI IN THE BATHING AREA.

The level of *E. coli* in the bathing area was tied fairly closely to the levels of fecal coliforms. On those days that the fecal coliform levels were extremely high, the *E. coli* levels were similarly high. These high levels of *E. coli* indicated that the bathing area was contaminated by intestinal wastes.

3. PATHOGENS IN WATERFOWL WASTES

During this study, analysis for pathogenic bacteria was not undertaken. Therefore, there was no first hand indication that pathogenic organisms were present in the water of the bathing area. Since the fecal wastes in the bathing area were found to come primarily from waterfowl, the question of the potential health risk of bathing in these waters arises.

A number of different workers over a number of years have examined the wastes of waterfowl for pathogenic organisms. Salmonellae have been found in some studies (6,7,8,9,10) but not in all flocks. Enteropathogenic *E. coli* were detected in a few Canada geese (4), *Edwardsiella tarda* in some gulls (6), *Listeria monocytogenes* in gulls (11), while *Campylobacter* was isolated from pigeons (12) and ducks and gulls (E. Harris, personal communication).

This list indicates that the detection of fecal wastes from waterfowl and other wildlife in a bathing area should be viewed with some concern. Therefore, beach placarding under these circumstances appears warranted.

CONCLUSIONS

1. Local sources at Chippewa Park were responsible for fecal bacterial contamination of the bathing area at Chippewa Beach.

2. There was no evidence in this study, and indeed, in the study conducted in 1985, to indicate that bacterial contaminants were reaching the primary bathing area from external sources via Lake Superior.

3. Heavy rainfall which caused stormwater runoff to enter the bathing area was the prime factor affecting the bacterial levels in the bathing area at Chippewa Beach.

4. The source of the fecal coliform bacteria in the bathing area at Chippewa Beach was the intestinal wastes of waterfowl and other wildlife that were normal inhabitants of the park. No other sources were found.

RECOMMENDATIONS

Recommendations for remedial action to correct the recurring problem of fecal coliform contamination of the bathing area at Chippewa Beach are beyond the scope of this portion of the Chippewa Beach Joint Study. Remedial measures will be addressed in a later report.

1. The presence of waterfowl, particularly the flock of Canada geese, and bathing activities at Chippewa Park are currently incompatible. Unfortunately, both of these aspects of Chippewa Park are pleasing: the first to wildlife watchers and the second to bathers. The Parks and Recreation Department must decide which of these two aspects will take priority at this park.

2. The system for erecting placards should be reviewed and streamlined. The automatic erection of placards by park staff based on events such as heavy rainfall or increased turbidity in the bathing area should be examined. This would provide greater public health protection than the current system.

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